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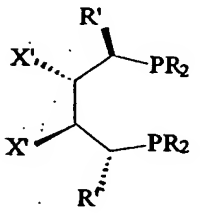
WHAT IS CLAIMED IS:

1. A ligand selected from the group consisting of compounds represented by **I** through **XI**: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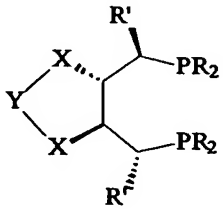
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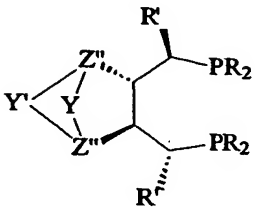
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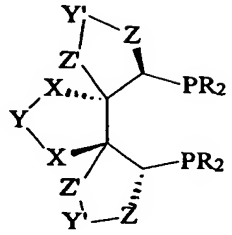
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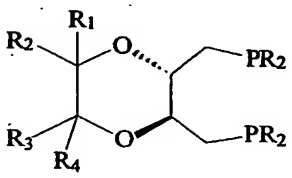
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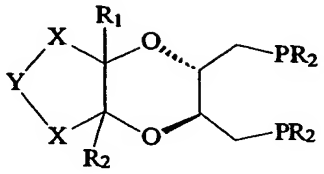
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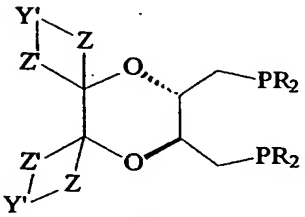
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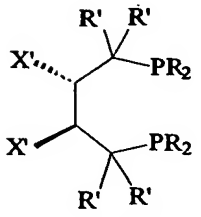
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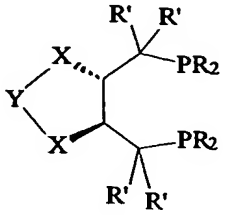
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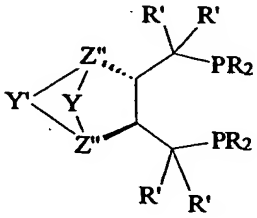
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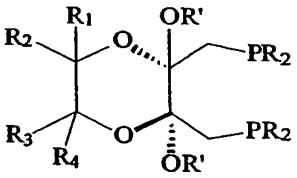
XI

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wherein X' is selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, hydroxy, alkoxy, aryloxy, siloxy, thioalkoxy, arylthio, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino, amido, ester, reverse ester, keto, halo, silyl and SH;

wherein R' is selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, hydroxy, alkoxy, aryloxy, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino and amido;

wherein each X, Z and Z' is independently selected from the group consisting of: O, NH, NR, CH_2, CHR, CR_2, C=O, S, SO_2, and SO;

wherein each Z" is independently selected from the group consisting of: N, P, CH, and CR;

wherein each R_1, R_2, R_3 and R_4 is independently selected from the group consisting of: H, alkyl, aryl, substituted alkyl, substituted aryl and OR;

wherein each Y and Y' is independently selected from the group consisting of: a diol protecting group residue, O, CO, $C(OR)_2$, CH(OR), CH_2, CHR, CR_2, CR_2, NR, SO_2, $-(CH_2)_n-$ wherein n is 0 or an integer from 1 to 8, $-(CH_2)_nQ(CH_2)_m-$ wherein each n and m is independently an integer from 1 to 8, divalent phenyl, substituted divalent phenyl, 2,2'-divalent-1,1'-biphenyl, substituted 2,2'-divalent-1,1'-biphenyl, 2,2'-divalent-1,1'-binaphthyl, substituted 2,2'-divalent-1,1'-binaphthyl, 1,1'-ferrocene, substituted 1,1'-ferrocene, wherein the substituent in each of said substituted divalent phenyl, biphenyl, binaphthyl and ferrocene is one or more moiety each independently selected from the group consisting of: alkyl, aryl, aralkyl, alkaryl, alkenyl, akkynyl, F, Cl, Br, I, OH, OR, SH, SR, COOH, COOR, SO_3H, SO_3R, PO_3H_2, PO_3HR, PO_3R_2, NH_2, NHR, NR_2, PR_2, AsR_2, SbR_2 and nitro; and

wherein each R is independently selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, fluoroalkyl, perfluoroalkyl and $-CR'_2(CR'_2)_qQ(CR'_2)_pR'$ wherein each q and p is independently an integer from 1 to 8, Q is selected from the group consisting of: O, S, NR, PR, AsR, SbR, divalent aryl, divalent fused aryl, divalent 5-membered ring heterocycle and divalent fused heterocycle.

2. The ligand of claim 1, wherein said ligand is a racemic mixture of enantiomers.

3. The ligand of claim 1, wherein said ligand is a non-racemic mixture of enantiomers.

4. The ligand of claim 1, wherein said ligand is one of the enantiomers.

5. The ligand of claim 1, having an optical purity of at least 85% ee.

6. The ligand of claim 1, having an optical purity of at least 95% ee.

7. The ligand of claim 1, wherein said ligand is supported on a support material.

8. The ligand of claim 7, wherein said support is selected from the group consisting of: a polymer support and an inorganic support.

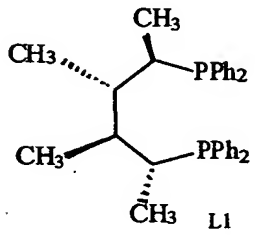
9. The ligand of claim 8, wherein said polymer support is selected from the group consisting of polystyrene, polyacrylate, resin, polyethylene glycol, methoxy polyethylene glycol, dendritic polyester and dendritic polyenamide.

10. The ligand of claim 8, wherein said inorganic support is selected from the group consisting of: silica, alumina, zeolite and molecular sieve.

11. The ligand of claim 8, wherein said ligand is linked to a support material by a linker group selected from the group consisting of: $NH(CH_2)_nSi(OEt)_3$, $CO(CH_2)_nSi(OEt)_3$, $(CH_2)_nSi(OEt)_3$, C-O, C-N and and NCF_2 linker, wherein n = 1 to 8.

12. The ligand of claim 1, including at least one water soluble functional group selected from the group consisting of: sulfonic, phosphoric and carboxylic.

13. A ligand selected from the group consisting of:



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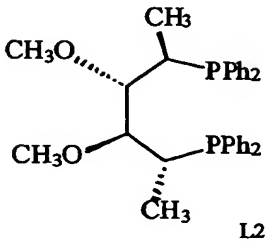

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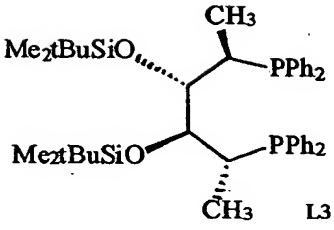

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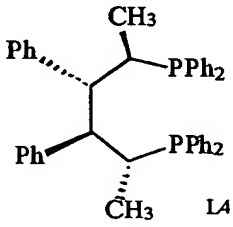

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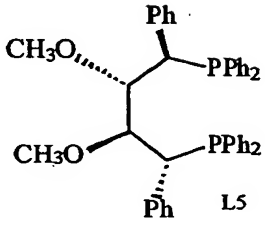

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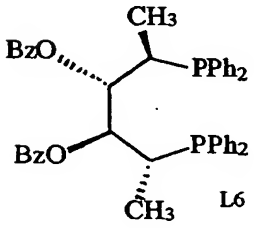

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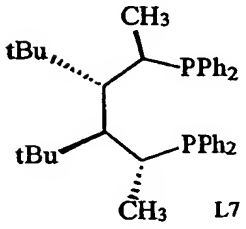

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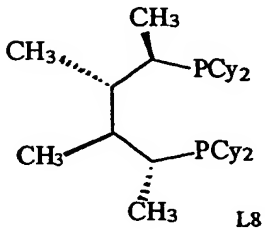

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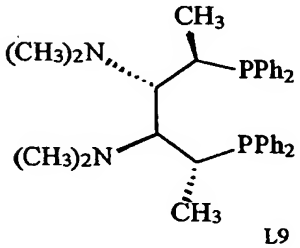

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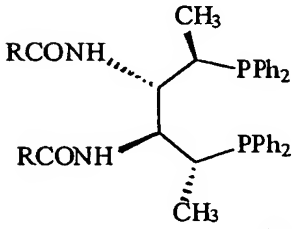

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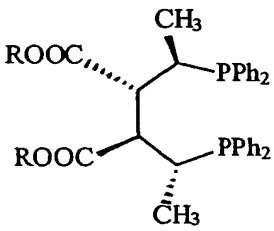

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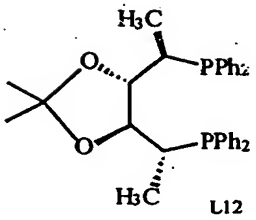
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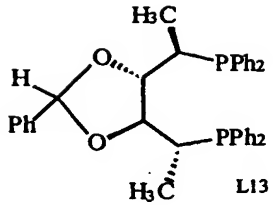
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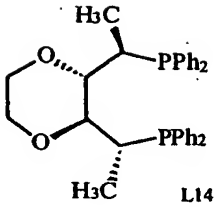
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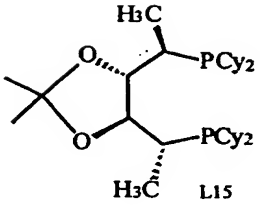
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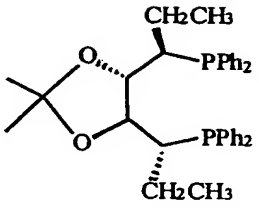
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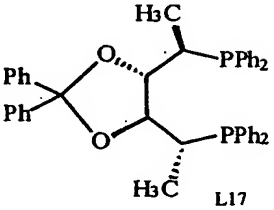
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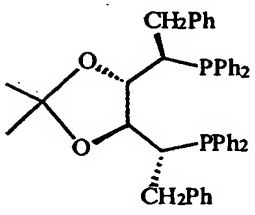
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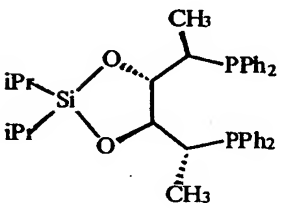
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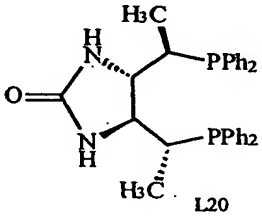
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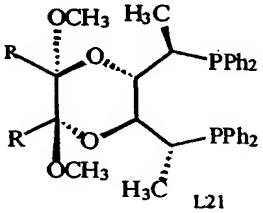
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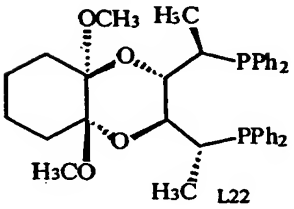
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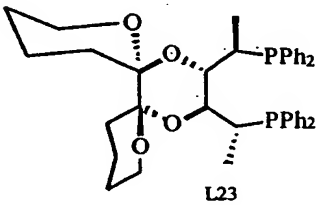
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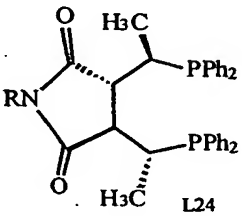
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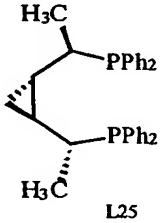
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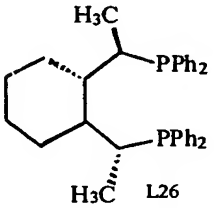
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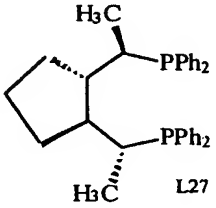
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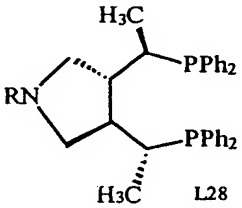
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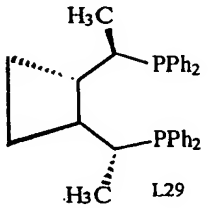
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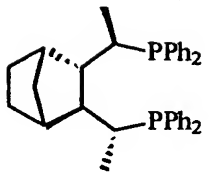

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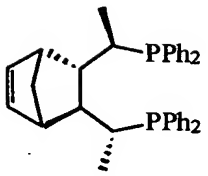

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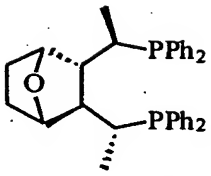

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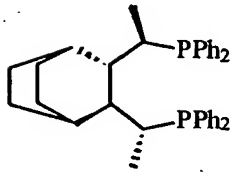

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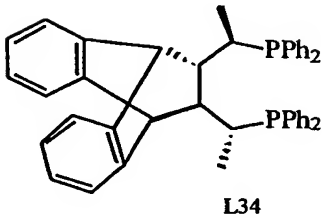

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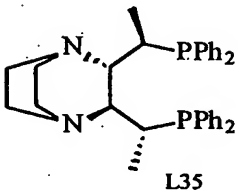

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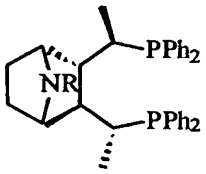

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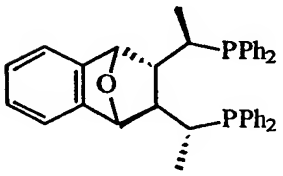

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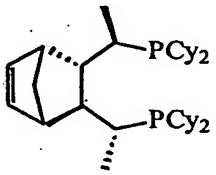

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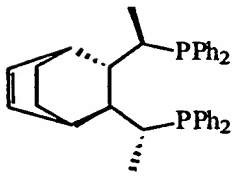

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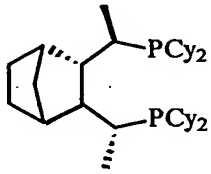

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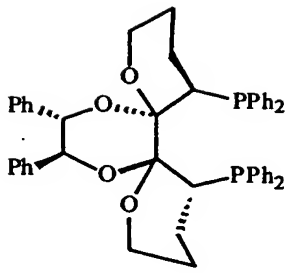

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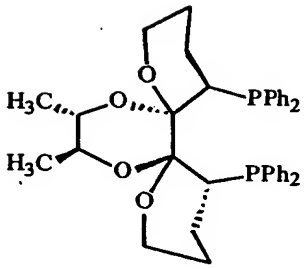

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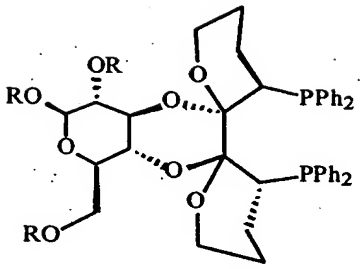

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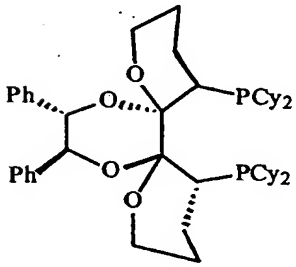

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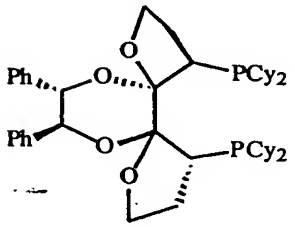

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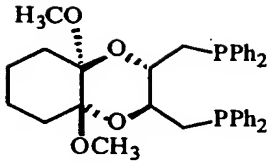

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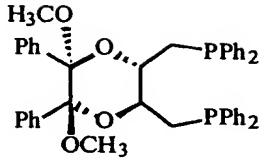

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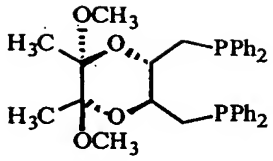

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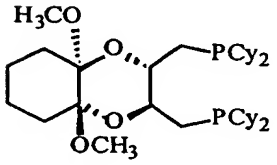

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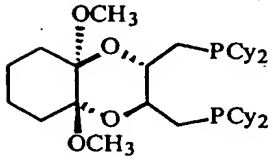

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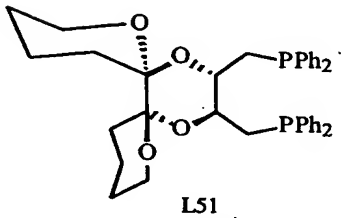

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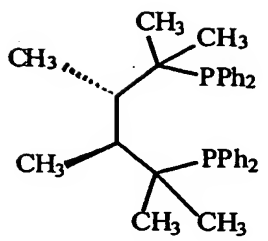

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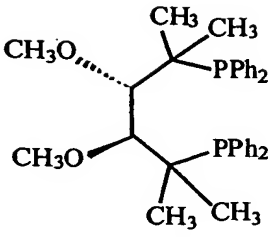

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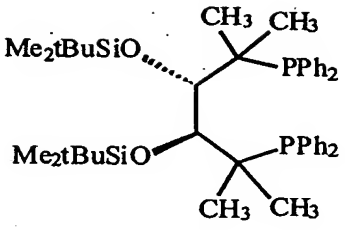

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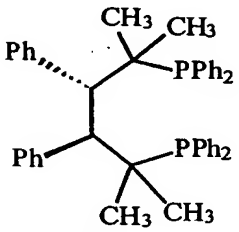

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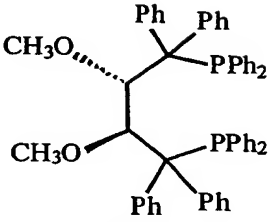

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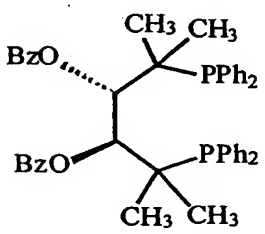

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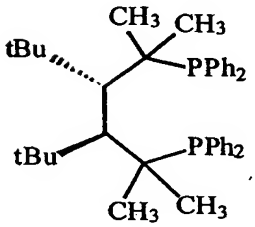

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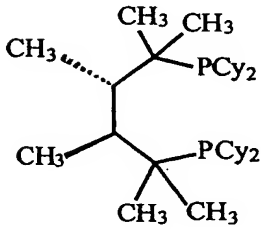

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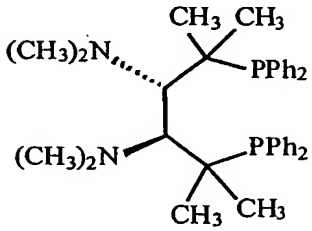

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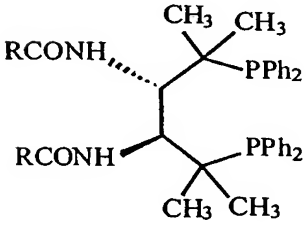

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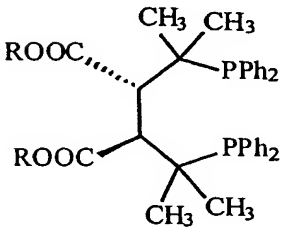

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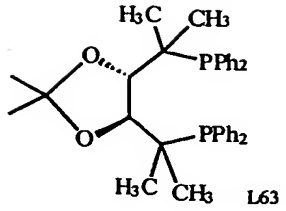
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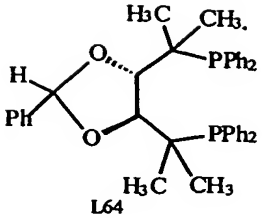
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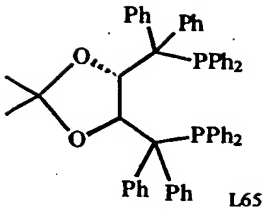
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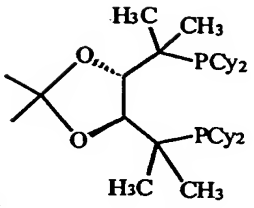
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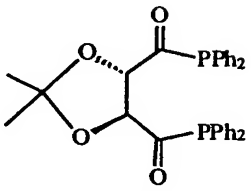
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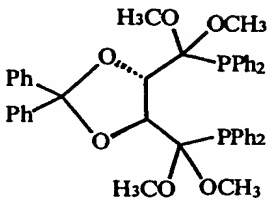
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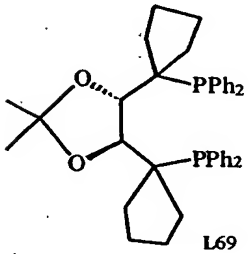
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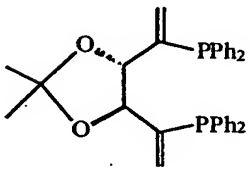
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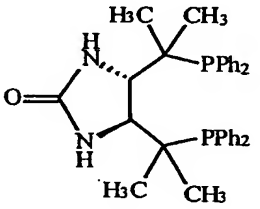
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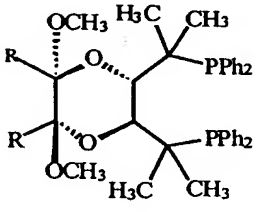
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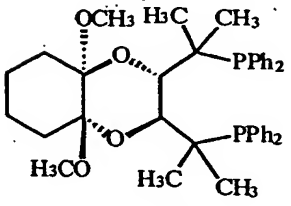
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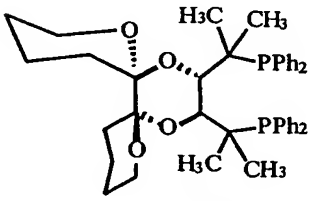
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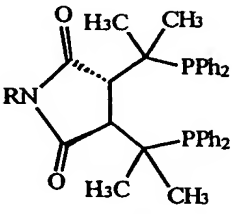
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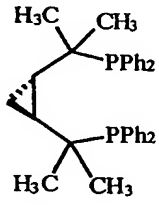
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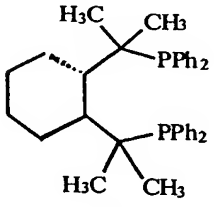
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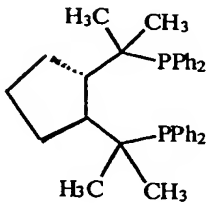
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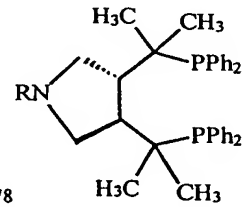
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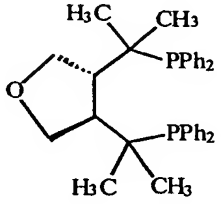
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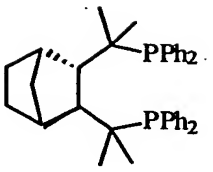

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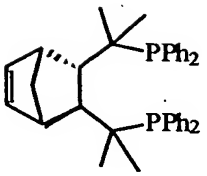

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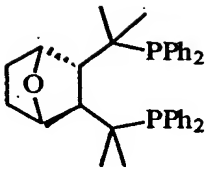

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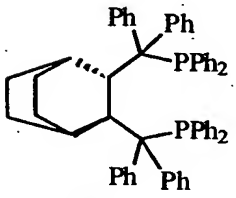

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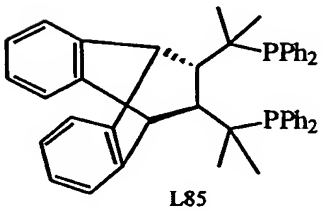

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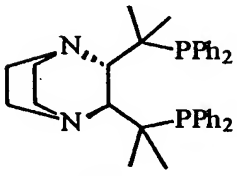

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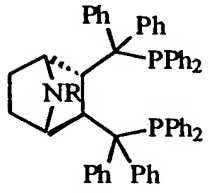

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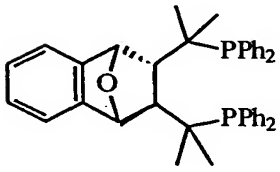

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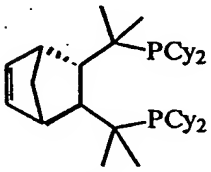

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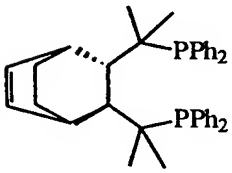

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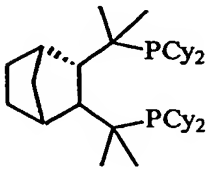
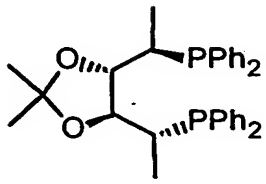


L91

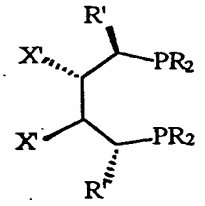
10

14. A ligand represented by the formula:

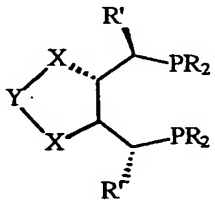


(R,S,S,R)-DIOP*

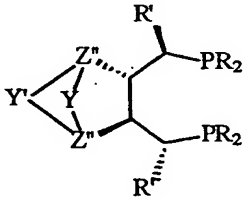
15. A catalyst prepared by a process comprising: contacting a transition metal salt, or a complex thereof, and a ligand selected from the group consisting of compounds represented by **I** through **XI**:



I



II



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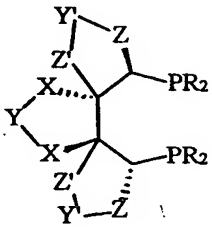

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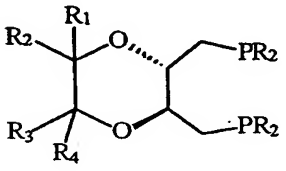

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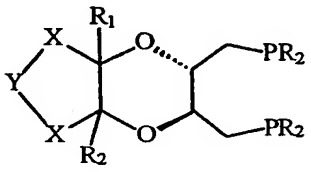

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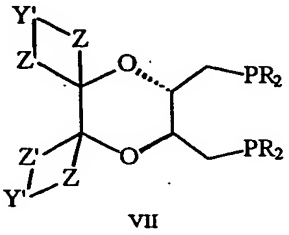

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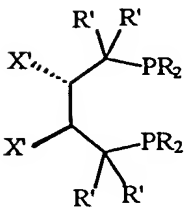

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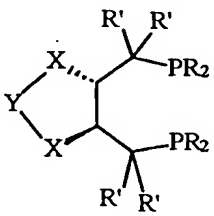
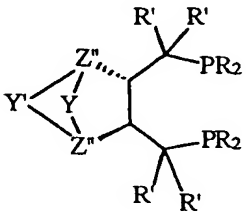


IX



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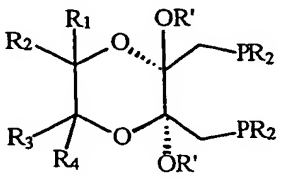


XI

wherein X' is selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, hydroxy, alkoxy, aryloxy, siloxy, thioalkoxy, arylthio, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino, amido, ester, reverse ester, keto, halo, silyl and SH;

wherein R' is selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, hydroxy, alkoxy, aryloxy, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino and amido;

wherein each X, Z and Z' is independently selected from the group consisting of: O, NH, NR, CH_2, CHR, CR_2, C=O, S, SO_2, and SO;

wherein each Z" is independently selected from the group consisting of: N, P, CH, and CR;

wherein each R_1, R_2, R_3 and R_4 is independently selected from the group consisting of: H, alkyl, aryl, substituted alkyl, substituted aryl and OR;

wherein each Y and Y' is independently selected from the group consisting of: a diol protecting group residue, O, CO, $C(OR)_2$, CH(OR), CH_2, CHR, CR_2, CR_2, NR, SO_2, $-(CH_2)_n-$ wherein n is 0 or an integer from 1 to 8, $-(CH_2)_nQ(CH_2)_m-$ wherein each n and m is independently an integer from 1 to 8, divalent phenyl, substituted divalent phenyl, 2,2'-divalent-1,1'-biphenyl, substituted 2,2'-divalent-1,1'-biphenyl, 2,2'-divalent-1,1'-binaphthyl, substituted 2,2'-divalent-1,1'-binaphthyl, 1,1'-ferrocene, substituted 1,1'-ferrocene, wherein the substituent in each of said substituted divalent phenyl, biphenyl, binaphthyl and ferrocene is one or more moiety each independently selected from the group consisting of: alkyl, aryl, aralkyl, alkaryl, alkenyl, akkynyl, F, Cl, Br, I, OH, OR, SH, SR, COOH, COOR, SO_3H, SO_3R, PO_3H_2, PO_3HR, PO_3R_2, NH_2, NHR, NR_2, PR_2, AsR_2, SbR_2 and nitro; and

wherein each R is independently selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, fluoroalkyl, perfluoroalkyl and $-CR'_2(CR'_2)_qQ(CR'_2)_pR'$ wherein each q and p is independently an integer from 1 to 8, Q is selected from the group consisting of: O, S, NR, PR, AsR, SbR,

divalent aryl, divalent fused aryl, divalent 5-membered ring heterocycle and divalent fused heterocycle.

16. The catalyst of claim 15, wherein said catalyst is a racemic mixture of enantiomers.

17. The catalyst of claim 15, wherein said catalyst is a non-racemic mixture of enantiomers.

18. The catalyst of claim 15, wherein said catalyst is one of the enantiomers.

19. The catalyst of claim 15, having an optical purity of at least 95% ee.

20. The catalyst of claim 15, wherein said transition metal is selected from the group consisting of: Pt, Pd, Rh, Ru, Ir, Cu, Ni, Mo, Ti, V, Re and Mn.

21. The catalyst of claim 15, wherein said transition metal is selected from the group consisting of: Pd, Rh, Ru and Ir.

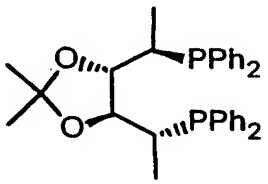
22. The catalyst of claim 20, wherein said transition metal salt, or complex thereof, is selected from the group consisting of: $PtCl_2$; $Pd_2(DBA)_3$; $Pd(OAc)_2$; $PdCl_2(RCN)_2$; $(Pd(allyl)Cl)_2$; $(Rh(COD)Cl)_2$; $(Rh(COD)_2)X$; $Rh(acac)(CO)_2$; $Rh(ethylene)_2(acac)$; $Rh(CO)_2Cl_2$; $Ru(RCOO)2(diphosphine)$; $Ru(methylallyl)2(diphosphine)$; $Ru(aryl\ group)X_2(diphosphine)$; $RuCl_2(COD)$; $(Rh(COD)_2)X$; $RuX_2(diphosphine)$; $RuCl_2(=CHR)(PR'_3)_2$; $Ru(ArH)Cl_2$; $Ru(COD)(methylallyl)_2$; $(Ir(COD)_2Cl)_2$; $(Ir(COD)_2)X$; $Cu(OTf)$; $Cu(OTf)_2$; $Cu(Ar)X$; CuX; NiX_2; $Ni(COD)_2$; $MoO_2(acac)_2$; $Ti(OiPr)_4$; $VO(acac)_2$; $MeReO_3$; MnX_2 and $Mn(acac)_2$; wherein each R and R' is independently

selected from the group consisting of: alkyl or aryl; Ar is an aryl group; and X is a counteranion.

23. The catalyst of claim 22, wherein said counteranion X is selected from the group consisting of: halogen, BF_4, $B(Ar)_4$ wherein Ar is 3,5-di-trifluoromethyl-1-phenyl, ClO_4, SbF_6, CF_3SO_3, RCOO and a mixture thereof.

24. The catalyst of claim 15, prepared in situ or as an isolated compound.

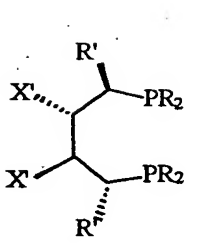
25. A catalyst prepared by a process comprising: contacting a ruthenium salt, or a complex thereof, and a ligand represented by the formula:



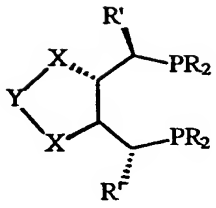
(R,S,S,R)-DIOP*

26. A process for preparation of an asymmetric compound comprising:

contacting a substrate capable of forming an asymmetric product by an asymmetric reaction and a catalyst prepared by a process comprising: contacting a transition metal salt, or a complex thereof, and a ligand selected from the group consisting of compounds represented by I through XI:



I



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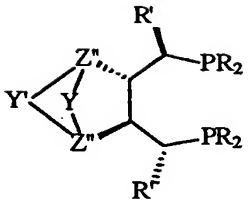

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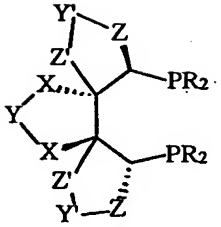

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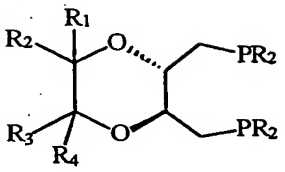

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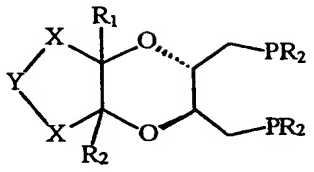

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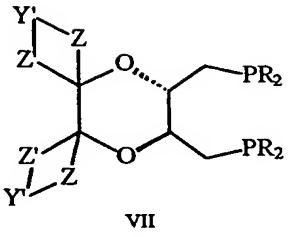
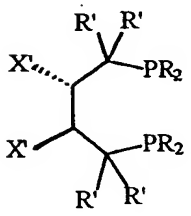
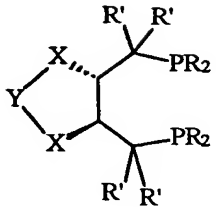


VII



VIII



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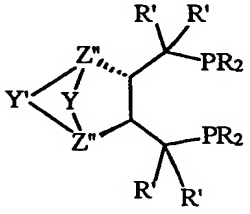

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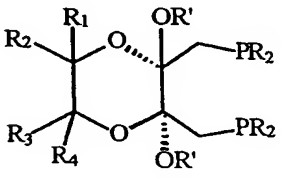

XI

wherein X' is selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, hydroxy, alkoxy, aryloxy, siloxy, thioalkoxy, arylthio, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino, amido, ester, reverse ester, keto, halo, silyl and SH;

wherein R' is selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, hydroxy, alkoxy, aryloxy, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino and amido;

wherein each X, Z and Z' is independently selected from the group consisting of: O, NH, NR, CH_2, CHR, CR_2, C=O, S, SO_2, and SO;

wherein each Z" is independently selected from the group consisting of: N, P, CH, and CR;

wherein each R_1, R_2, R_3 and R_4 is independently selected from the group consisting of: H, alkyl, aryl, substituted alkyl, substituted aryl and OR;

wherein each Y and Y' is independently selected from the group consisting of: a diol protecting group residue, O, CO, $C(OR)_2$, CH(OR), CH_2, CHR, CR_2, CR_2, NR, SO_2, $-(CH_2)_n-$ wherein n is 0 or an integer from 1 to 8, $-(CH_2)_nQ(CH_2)_m-$ wherein each n and m is independently an integer from 1 to 8, divalent phenyl, substituted divalent phenyl, 2,2'-divalent-1,1'-biphenyl, substituted 2,2'-divalent-1,1'-biphenyl, 2,2'-divalent-1,1'-binaphthyl, substituted 2,2'-divalent-1,1'-binaphthyl, 1,1'-ferrocene, substituted 1,1'-ferrocene, wherein the substituent in each of said substituted divalent phenyl, biphenyl, binaphthyl and ferrocene is one or more moiety each independently selected from the group consisting of: alkyl, aryl, aralkyl, alkaryl, alkenyl, akkynyl, F, Cl, Br, I, OH, OR, SH, SR, COOH, COOR, SO_3H, SO_3R, PO_3H_2, PO_3HR, PO_3R_2, NH_2, NHR, NR_2, PR_2, AsR_2, SbR_2 and nitro; and

wherein each R is independently selected from the group consisting of: alkyl, aryl, substituted alkyl, substituted aryl, fluoroalkyl, perfluoroalkyl and $-CR'_2(CR'_2)_qQ(CR'_2)_pR'$ wherein each q and p is independently an integer from 1 to 8, Q is selected from the group consisting of: O, S, NR, PR, AsR, SbR, divalent aryl, divalent fused aryl, divalent 5-membered ring heterocycle and divalent fused heterocycle.

27. The process of claim 26, wherein said asymmetric reaction is selected from the group consisting of: hydrogenation, hydride transfer, allylic

alkylation, hydrosilylation, hydroboration, hydrovinylation, hydroformylation, hydrocarboxylation, isomerization, cyclopropanation, Diels-Alder reaction, Heck reaction, isomerization, Aldol reaction, Michael addition and epoxidation.

28. The process of claim 27, wherein said asymmetric reaction is hydrogenation and said substrate is selected from the group consisting of: imine, ketone, ethylenically unsaturated compound, enamine, enamide and vinyl ester.

29. The process of claim 27, wherein said substrate is an electron-rich substrate.

30. The process of claim 26, wherein said catalyst is an Rh complex of (R,S,S,R)-DIOP*.

31. The process of claim 26, wherein said catalyst is an Rh complex of
ligand **18**.

32. A process for preparing a ligand enantiomer comprising the steps of:

contacting an enantiomer of tartaric acid diester and a diol protecting group in the presence of an acid catalyst to produce a bis-protected tartrate diester;

contacting said bis-protected tartrate diester and a reducing agent to convert the ester functional groups in said tartaric acid diester to a diol;

converting said diol to a sulfonate ester; and

displacing the sulfonate group in said sulfonate ester with lithium diphenylphosphinide to produce ligand enantiomer.